

Aug. 31, 1948.

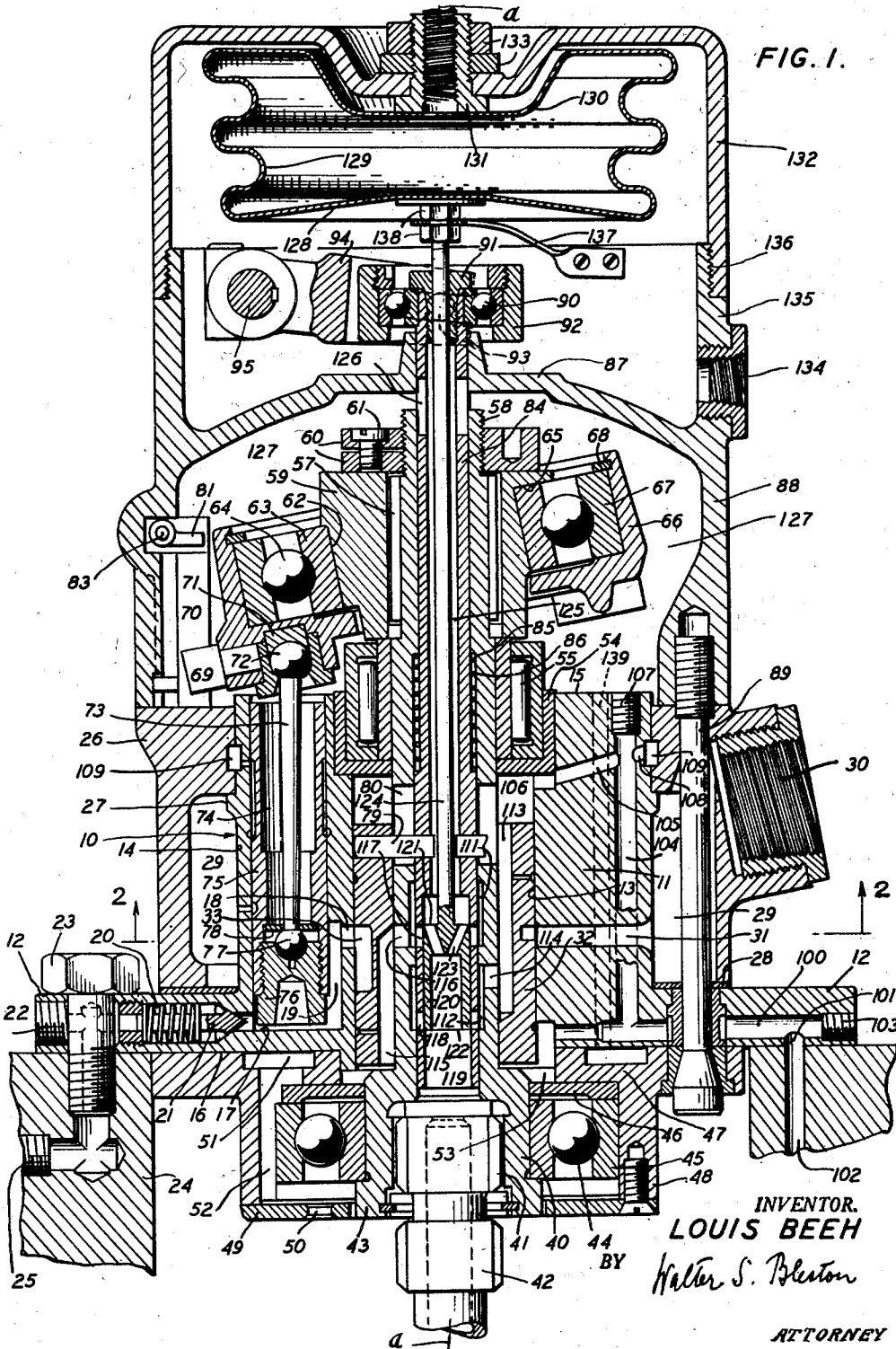
L. BEEH

2,448,347

HYDRAULIC PUMP CONTROL

Filed Oct. 18, 1944

5 Sheets-Sheet 1



Aug. 31, 1948.

L. BEEH

2,448,347

HYDRAULIC PUMP CONTROL

Filed Oct. 18, 1944

5 Sheets-Sheet 2

FIG. 2.

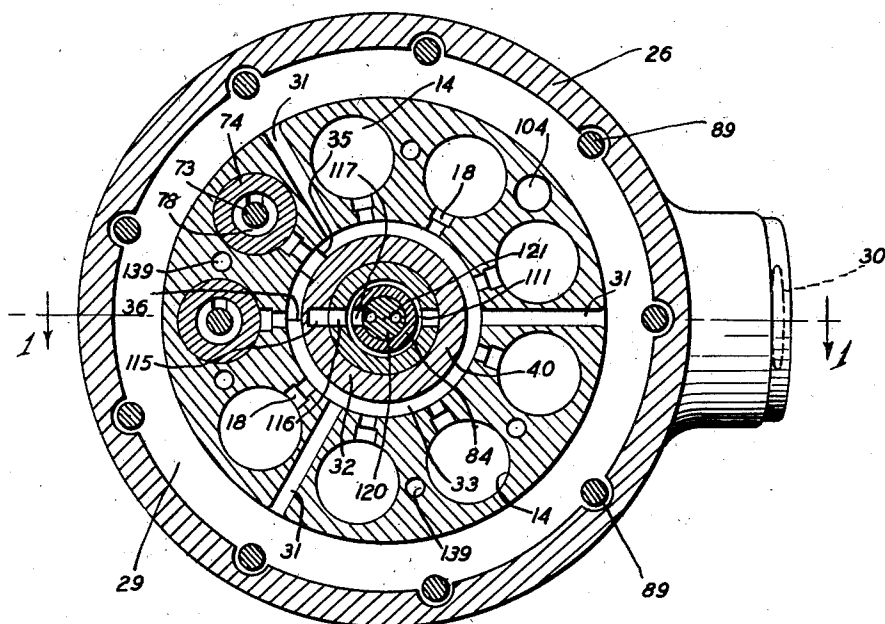
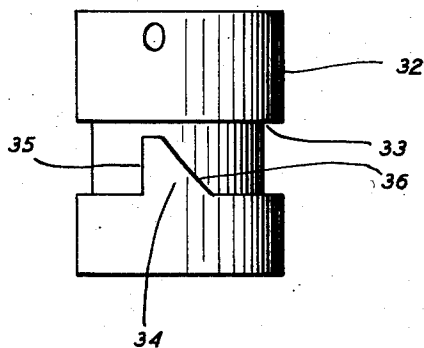


FIG. 3.



INVENTOR.
LOUIS BEEH
BY *Walter S. Blanton*
ATTORNEY

Aug. 31, 1948.

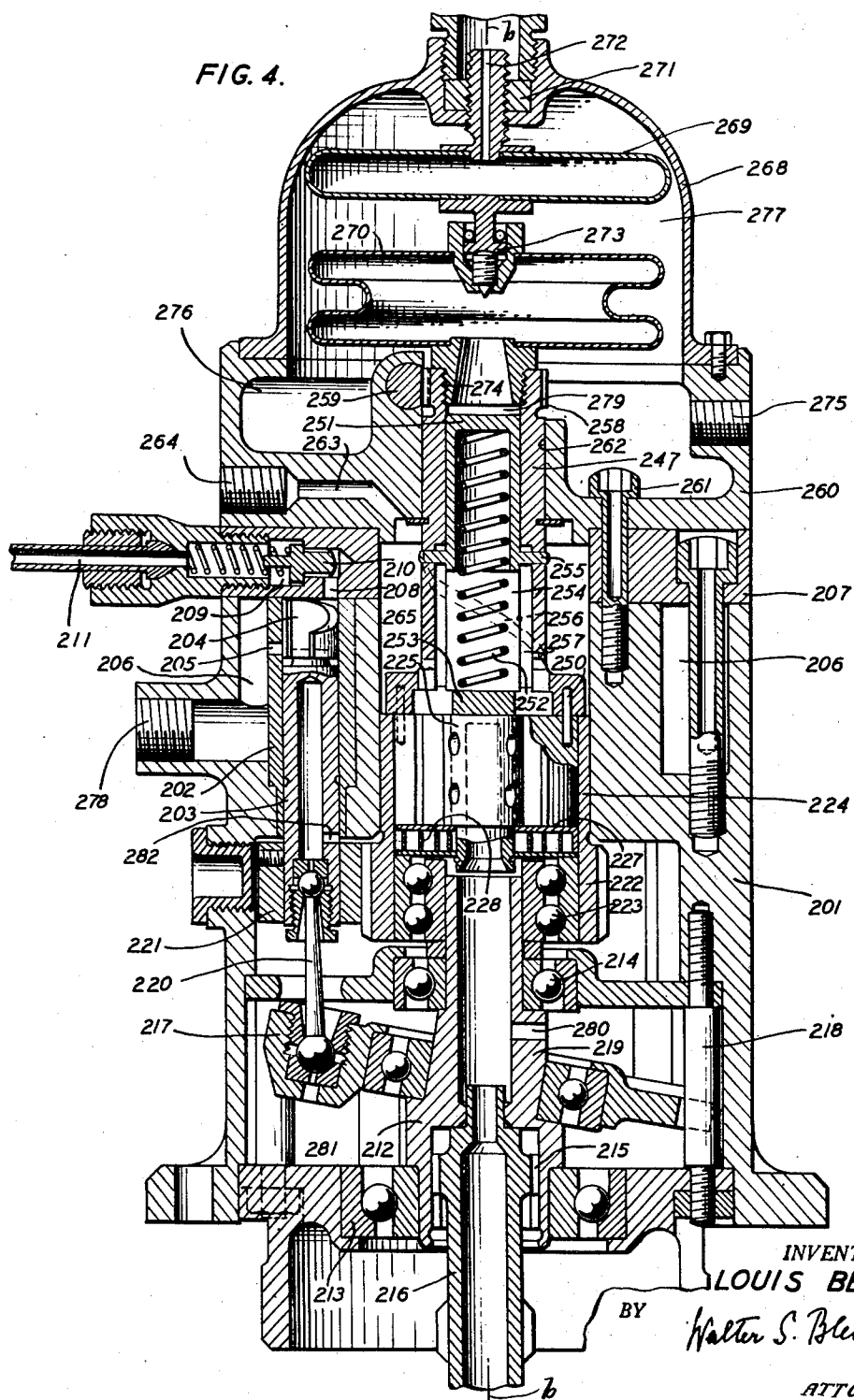
L. BEEH

2,448,347

HYDRAULIC PUMP CONTROL

Filed Oct. 18, 1944

5 Sheets-Sheet 3



Aug. 31, 1948.

L. BEEH

2,448,347

HYDRAULIC PUMP CONTROL

Filed Oct. 18, 1944

5 Sheets-Sheet 4

FIG. 7.

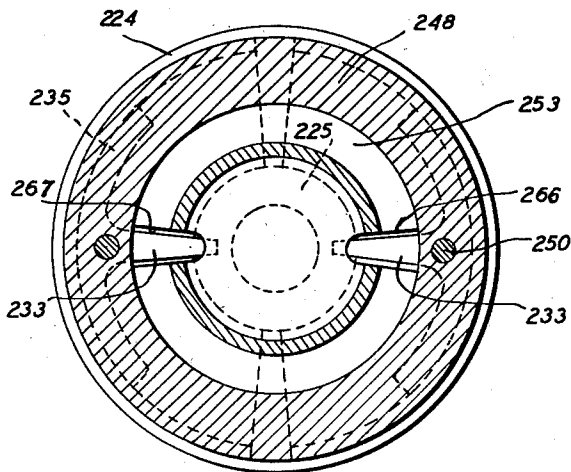


FIG. 6.

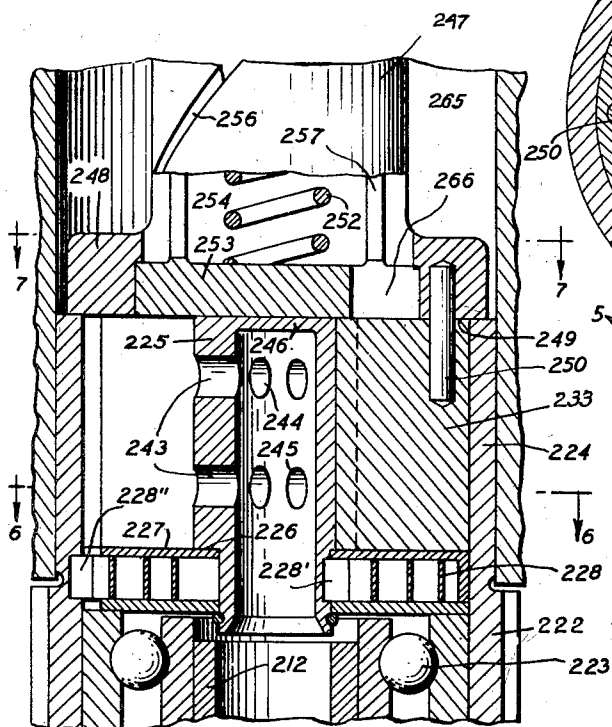
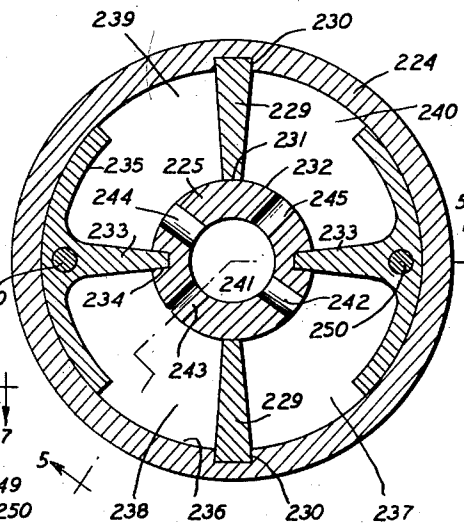


FIG. 5.

INVENTOR.
LOUIS BEEH
BY *Walter S. Pleston*

ATTORNEY

Aug. 31, 1948.

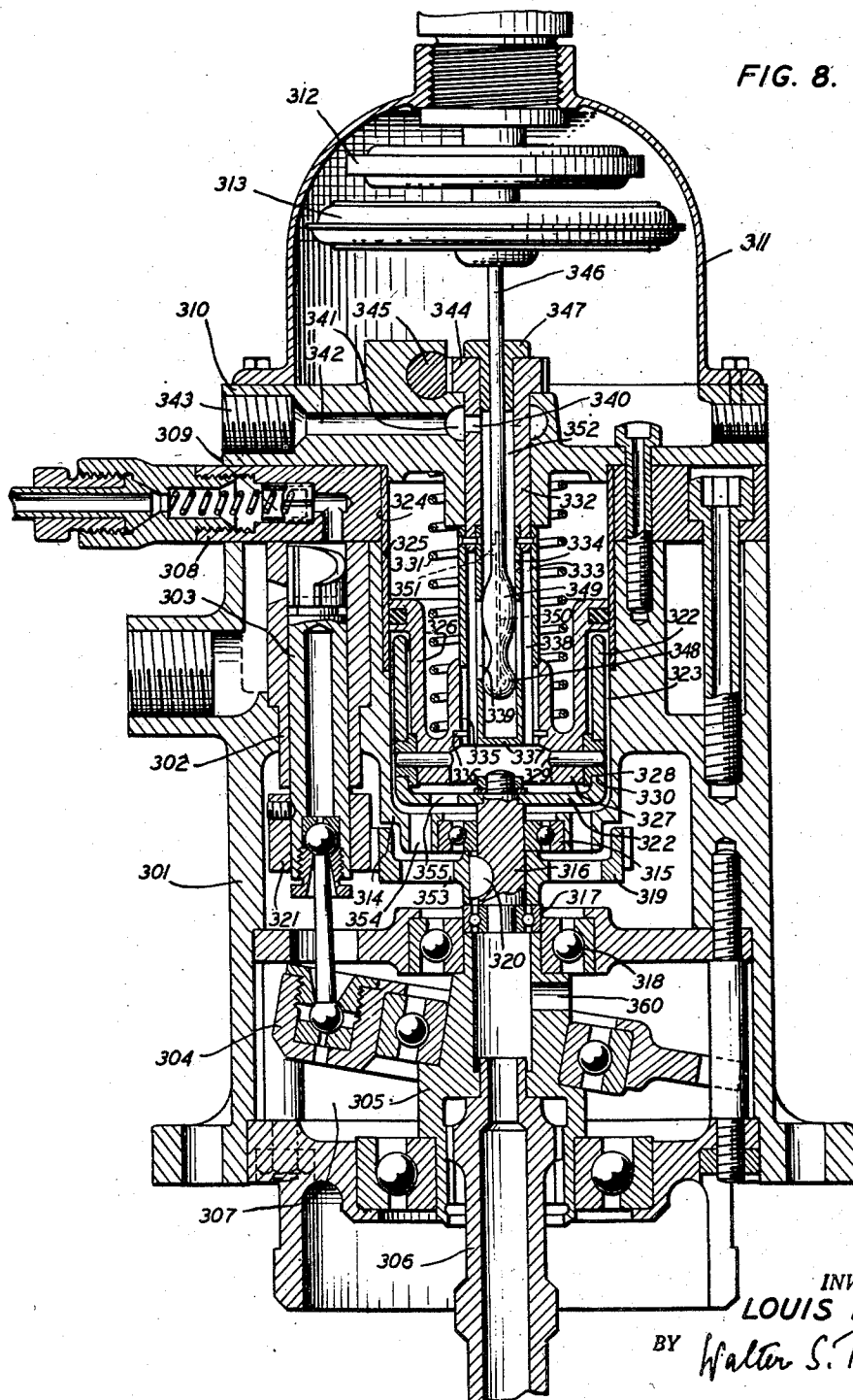
L. BEEH

2,448,347

HYDRAULIC PUMP CONTROL

Filed Oct. 18, 1944

5 Sheets-Sheet 5



INVENTOR.
LOUIS BEEH
Walter S. Bleston

ATTORNEY

UNITED STATES PATENT OFFICE

2,448,347

HYDRAULIC PUMP CONTROL

Louis Beeh, Long Meadow, Mass., assignor to
Bulova Watch Company, Inc., New York, N. Y.,
a corporation of New York

Application October 18, 1944, Serial No. 559,295

18 Claims. (Cl. 103—38)

1

2

The invention relates to a multiple pump, and more in particular, to a fuel injection pump for multiple cylinder engines, and contemplates the provision of certain improvements applicable with particular advantages to that type of pumps in which a plurality of units comprising a barrel and a plunger therein are arranged parallel to and equidistant from a main axis, and wherein each plunger is reciprocable once during each cycle of the pump operation, with a phase displacement in relation to the preceding plunger. Examples of such pumps are disclosed, e. g. in my U. S. Patent No. 2,391,221 of December 18, 1945, wherein a common rotatable valve controls certain parts of the barrels, and in my U. S. Patent No. 2,388,462, November 6, 1945, wherein each plunger is provided with a helical head controlling a barrel port for metering the quantity of fuel to be discharged. However, it will be understood that the invention is not limited in its application to a particular type of pumps. Pumps of the kind under consideration are frequently provided with a device comprising a diaphragm or a bellows which in response to certain external pressure variations serves to adjust the control elements in order to adapt the pump output to the operating condition of the connected engine. If, in such an event, a high degree of sensitivity is desired, large and bulky bellows or the like are required in order to furnish sufficient power and stroke for adjustment. The invention aims, therefore, to avoid such drawback, and it consists essentially in the provision of hydraulic means to shift the control elements for output adjustment in response to pressure variations as occurring, e. g. in the manifold of an engine to which the engine may be applied.

According to another object of the invention a lubricant may be used as the pressure medium of the hydraulic means, the same lubricant serving to lubricate the movable parts of the pump.

The invention also contemplates the use of oil from the lubricating system of an engine to which the pump may be applied as the pressure medium of said hydraulic means.

Further objects and details of the invention will be apparent from the description given hereinafter and the accompanying drawing showing embodiments thereof by way of example. In the drawing:

Fig. 1 is a longitudinal section of an embodiment of the invention, the section being taken along line 1—1 of Fig. 2;

Fig. 2 is a cross-section along lines 2—2 of Fig. 1;

Fig. 3 is a development of the metering valve of the pump of Fig. 1;

Fig. 4 is a longitudinal section of another embodiment;

5 Fig. 5 is a longitudinal cross-section of the central part of the pump of Fig. 4 on a larger scale and taken along line 5—5 of Fig. 6;

Figs. 6 and 7 are cross-sections along lines 6—6 and 7—7 respectively of Fig. 5; and

10 Fig. 8 is a longitudinal cross-section of a modification of the pump of Fig. 4.

Referring now to the drawing, Figs. 1 to 4 illustrate by way of example a pump according to the invention and destined for use with a nine cylinder engine. The pump belongs to the type in which the output of each unit is controlled by a common valve. The pump comprises a block in general denoted by 10 which consists of a substantially cylindrical portion 11 with a flange 12 at its lower end, and which has an axial bore 13 throughout its length. Nine other bores 14 are provided parallel to and equidistant from the main pump axis *a—a*. They reach from the top face 15 of the block not quite to the other end face 16 which is the lower face of the flange 12 so that each bore 14 constitutes a barrel with a bottom 17. At a distance upward from the bottom 17, a radial port 18 opens from the barrel into the space of the bore 13, and a groove 19 in the interior of the barrel reaches from the port 18 downward to the bottom 17. The flange 12 is provided with radial bores 20, one for each barrel, and communicating with the bottom end of the latter. Each bore 20 is so formed as to constitute a chamber for a spring biased delivery valve 21. The outer end of each bore 20 is closed by a plug 22, and a hollow screw bolt 23 crosses the bore 20 and serves the dual purpose of securing the pump to a flange or other portion 24 of an engine, and of connecting the bore 20 to a conduit 25 leading to the nozzle (not shown) of an engine cylinder.

A substantially cylindrical jacket or housing 26 bears on an outer shoulder 27 of the block 10 and also on a gasket ring 28 on top of flange 12. An annular fuel chamber 29 with an inlet 30 is formed between the housing 26 and block 10, and radial conduits 31 in the block 10 intermediate said barrels connect said chamber and the inner 50 bore 13 of the block 10. Interiorly of the bore 13, a valve 32 shaped as a hollow piston is arranged so as to be rotatable and axially shiftable by means to be described hereinafter. The valve, the development of which is shown in Fig. 3 has 55 a peripheral recess 33 with a land 34 thereon to

close the ports 18, one after the other during its rotation, for a shorter or longer part of each revolution depending on whether a narrower or wider part of the land is in registry with the ports. However, it is to be noted that the recess 33 is in permanent communication with chamber 29 through at least some of the conduits 31.

Coaxially with the block 10 and extending through valve 32, a hollow drive shaft 40 is arranged which is interiorly splined in its lower end portion at 41 in order to be coupled with a shaft 42 of the engine to which the pump is to be applied. The shaft 40 is provided with an end collar or flange 43 and journaled in a bearing 44 which in the illustrated embodiment is a ball bearing acting as a collar bearing as well as a thrust bearing. The outer race 45 of bearing 44 engages a ring 46 which in turn bears on an inner flange 47 of a casing 48 secured to the lower face 16 of the block 10. The casing is closed by a lower cover plate 49 with an opening 50, and it is so shaped as to form with the lower face of the block an annular recess 51 communicating with the opening 50 via a groove 52 in the inner wall of the casing. Another annular space 53 in communication with the axial bore 13 of block 10 is formed between the casing 48, ring 46 and shaft 40. Shaft 40 is journaled in a second bearing such as needle bearing 55 supported by a cup-shaped member 54 which rests on an inner shoulder of the block 10. The shaft portion above the needle bearing is externally splined at 57, and the topmost end 58 is screw-threaded. To the splined portion, a shaft head 59 is secured by means of a slitted nut 60 screwed on the threading 58 and locked in position by a screw 61 which forces the slitted nut portions apart or together so as to deform a portion of the nut threading. The shaft head 59 has an outer cylindrical bearing surface 62 which is inclined with respect to the main axis $a-a$, and on which the inner race 63 of a ball bearing 64 is mounted so as to engage a head shoulder 65. A cup-shaped wobble or swash plate 66 is secured to the outer race 67 by means of a spring ring 68, and engages with a projection 69 stationary guide faces 70 arranged parallel to the axis $a-a$. When shaft 40 rotates, the swash plate will not participate in the rotation owing to the engagement of the projection 69 with the guide faces 70 but will accomplish a cyclical up and down motion. The swash plate is provided with ball sockets 71, as many as there are barrels in the block 10, so as to receive therein the upper ball heads 72 of connecting rods 73 of plungers 74 which are reciprocable in the barrels 14. Each plunger consists of a tubular body 75 with a lower head 76 screwed into the body end. The lower ball end 77 of each connecting rod is secured to an accordingly shaped recess of the head 76 of the associated plunger by a slotted retaining washer 78 bearing against an inner shoulder of the plunger tube 75. In order to rotate the metering valve while the plungers are reciprocated, a pin or pins 79 are secured in the valve body and engage the drive shaft 40 in slots 80 which permit axial adjustment of the valve relatively to the ports 18.

The pump so far described operates in the following manner: If the drive shaft is turned by the engine shaft 42, the plungers will be reciprocated according to the cyclical oscillation of the swash plate, i. e. each plunger lagging in phase in respect to the preceding one and the phase lag being equal to 360° divided by the number of plungers. While the plungers are thus reciprocated

the metering valve 32 rotates uniformly with the shaft 40. It is so adjusted in relation to the inclination of the shaft head 59 that each port 18 will be covered by the land 34 of the valve during a portion of the compression stroke of the coordinate plunger 73 and the length of such stroke portion will be determined by the width which the land has, according to its axial adjustment, between the edges 35 and 36 on the level of the ports 18. During the suction stroke of a plunger, fuel may therefore enter the coordinate barrel from space 29 through conduits 31, valve recess 33 and port 18. While the latter is closed during a portion of the compression stroke a corresponding quantity of fuel will be expelled by the plunger from its barrel through the delivery valve 21, and during the remainder of the compression stroke a corresponding quantity of fuel will be returned on the same way as that on which fuel entered during the suction stroke.

In order to adjust the valve 32 in axial direction for the purpose of metering the quantity of fuel delivered by the pump, a tubular rod 84 is arranged interiorly of shaft 40 and the pin or pins 79 are secured to said rod so that the valve and the rod will rotate in conjunction and will be axially shiftable together in relation to the shaft 40. A recess 85 is formed between the shaft and the tubular rod and a compression spring 86 in that recess tends to shift the rod and valve downward. The upper end of the tube 84 extends through the top wall 87 of an upper housing part 88 which encompasses the swash plate with its accessory parts and to which the aforementioned guide faces 70 are attached. The part 88 is connected to the lower housing 26, the block flange 12 and the casing 48 by means of a number of screw bolts 89 as clearly shown in Fig. 1. On the upwardly projecting end of the tubular rod 84 an anti-friction bearing 90 is mounted so as to abut against the flanged head of a hollow plug 91 screwed into the tubular rod 84. The bearing 90 is encased in a ring 92 having two diametrically opposite trunnions 93 which are engaged by a forked lever 94. The latter is mounted on a shaft 95 projecting laterally from the housing part 88 so as to be turned by suitable means not shown. Thus, if shaft 95 is turned in anti-clockwise direction, the tubular rod 84 together with valve 32 will be raised against the restraint of spring 86 while being free to rotate together with the drive shaft 40.

Means are provided for an automatic adjustability of the metering valve in response and according to pressure variations occurring in the manifold of the engine to which the pump is connected. Such automatic adjustability may be either instead of any other or may be in addition to one under the control of an operator. The illustrated embodiment shows a form which provides for such automatic adjustability in addition to that obtained by means of the lever 94 and accessory parts. According to the invention, the automatic adjustment of the metering valve is accomplished by a hydraulic system under the control of a small auxiliary valve actuated by a bellows which, thus, can be small in size and still fully effective for the contemplated purpose. Also, according to the invention, the hydraulic fluid used in the pump is the pressure lubricant which may be taken from the lubrication system of the engine to be charged by the pump, and which is anyway required to lubricate the movable parts of the pump. In the illustrated embodiment the flange 12 is provided with a radial conduit 100 communicating with the aforementioned annular

5

space 53 on top of the thrust bearing plate 46. The conduit 100 has a port 101 in the bottom face of the flange for connection to a branch of the engine lubrication system, indicated at 102. The outer end of the conduit is closed by a plug 103. However, it is of course also possible to admit the hydraulic fluid, i. e. preferably a lubricant from the outer end of the conduit when the plug 103 is removed and the port 101 is closed. The conduit 100 is arranged intermediate two adjacent delivery valve chambers 20 and has a vertical branch 104 closed at its upper end by a plug 107 and connected by a substantially radial arm 105 to the space 106 of the bore 13 on top of the metering valve 32; the aforementioned member 54 constitutes the upper confinement of the space 106. An outward extension 108 of the arm 105 opens into a ring groove 109 from which lubricating grooves of the plungers 74 are fed. Within the range of the valve 32 the shaft is provided with two relatively wide grooves 111 and 112, one above the other so that between the shaft and the tubular rod 84 two annular chambers are formed. The lower groove or chamber 112 communicates with space 106 through a groove 113 of the valve 32 and an opening 114 of the shaft. Similarly, the upper chamber 111 communicates with the space 53 through a groove 115 and an opening 116. The tubular rod 84 extends in its lowermost position far downward in shaft 40 and is provided with two ports or sets of ports 117 and 118. The dimensions are such that these ports are permanently in communication with the chambers 111 and 112 respectively, regardless of the relative position of the tubular rod in shaft 40. Interiorly of a cylindrical space 119 formed in the lower end of the tubular rod 84, an auxiliary slide valve 120 is axially movable. Valve 120 has an upper and a lower controlling edge, 121 and 122, respectively, so spaced from each other that the ports 117 and 118 are just closed in the illustrated position. It is shaped as a hollow cylinder and provided with passages 123 connecting the spaces of the cylinder above and below the valve with each other. The valve 120 is integral with or attached to a control rod 124 which extends upward through the entire length of the tubular rod 84 with ample clearance which constitutes a passage 125 from the space 119 through slots 126 in the upper portion of the tubular rod 84 to the swash plate chamber 127 formed by the upper housing part 88. The upper end of control rod 124 is guided in plug 91 of rod 84 and secured by suitable means such as a screw connection 138, to the lower wall 128 of a bellows 129. The top wall 130 of the bellows is attached to a tubular piece 131 passing through a housing cover 132 and held in position by nuts 133. The piece 131 opens into the bellows 129 and may be connected to the engine manifold so as to subject the bellows to the interior pressure prevailing therein. The exterior of the bellows is under atmospheric pressure owing to the opening 134 in an extension 135 of the upper housing part 88 to which extension the cover 132 is secured by a screw threading 136. The weight of the rod 124 may be compensated by means such as leaf spring 137 attached to the housing 88 and engaging between the parts 138 by which the rod is connected to the bellows 129. This spring may be so formed as to prevent the rod 124 from rotating.

The automatic adjustment of the metering valve by means of the device just described takes place in the following manner: In Fig. 1 the metering valve 32 with the tubular rod 84 and also the auxiliary valve 120 with its rod 124 are

6

in their lowermost positions and the bellows is not subject to a difference of external and internal pressure. The tubular rod 84 with valve 32 rotates with the drive-shaft 40 owing to their connection by pin 79 while the auxiliary valve and rod 124 do not participate in such rotation. The spaces 106 and 53 above and below the metering valve 32 are filled with a lubricant under pressure from conduit 100. If, now, the interior pressure of the bellows 129 decreases, the latter will contact and lift rod 124 with auxiliary valve 120. In consequence, the lower controlling edge will open the port 118 with the result that lubricant from space 106 can escape via groove 113, opening 114, shaft chamber 112, port 118, lower part of space 119, bores 123, upper part of space 119, passage 125 and slots 126, to splash upon the swash plate and other movable parts in the housing chamber 127. From there the lubricant can flow through conduits 139 to the ring recess 51 and further through groove 52 and opening 50 back to the lubricating system of the engine to which the pump may be connected. Owing to the escape of lubricant from space 106 the pressure on the lower face of valve 32 will be greater than the pressure on the upper face so that the valve together with the tubular rod 84 will be raised. This will continue until the port 118 has passed the edge 122 and is closed by the auxiliary valve. When this has happened, the flow of the lubricant in space 106 stops and the pressures on top and below the metering valve 32 will again be equalized, so that the valve 32 will remain in the adjusted position according to the contraction of the bellows 129. If then, the inside pressure of the bellows increases and the latter expands, the auxiliary valve 120 will be lowered and port 117 will be opened. In consequence the lubricant in the annular recess 53 underneath the valve 32 is free to flow off through the grooves, openings and passages 115, 116, 117, into the upper part of space 119, and on as just described with respect to the lubricant from space 116, so that the valve 32 will be lowered until the opening 117 has passed the control edge 121 of the auxiliary valve. Thus, the adjustment of the valve 32 will follow exactly the pressure conditions prevailing in the engine manifold with which the bellows communicates.

Whereas in the embodiment hereinbefore described, the type of pump is such that the control element is to be shifted in an axial direction for the purpose of adjusting the pump output, adjustment is accomplished in the embodiment which now will be described by a rotary movement derived, with the aid of hydraulic means, from an axial movement of a pressure responsive organ. The pump illustrated in Figs. 4 to 7 is of a kind as disclosed in my U. S. Patent No. 2,388,462 of November 6, 1945. In a housing 201 a number of pump barrels 202, for instance nine, are arranged parallel to and equidistant from the housing axis b-b. Interiorly of each barrel a reciprocable plunger 203 is provided with a helical head 204 the end face of which controls an inlet and metering port 205 from an annular fuel chamber 206 intermediate the outer wall of the housing 201 and the barrels 203. The housing and the barrels therein are covered by a valve plate 207 which is provided with a discharge conduit 208 for each barrel and each conduit is in communication with a radial chamber 209 containing a spring-biased discharge valve 210. The outer end of chamber 209 is so shaped that a pipe line 211 may

be connected thereto, through which fuel discharged from the associated pump barrel may be injected into the nozzle of an engine cylinder (not shown). Coaxially with the housing a hollow drive shaft 212 is mounted in bearings 213 and 214. The shaft is interiorly splined at 215 in its lower end for driving connection with a hollow shaft 216 which is part of the engine to which the pump may be applied. Mounted on shaft 212 is a wobble or swash plate 217 which is prevented from rotating by its engagement with a guide 218 so however, that the swash plate 217 is able to tilt cyclically about a shaft portion 219 which is inclined with respect to the main axis *b-b*. Each plunger 203 is connected to the swash plate 217 by a connecting rod 220 so that during each revolution of the shaft 212 each plunger 203 will be once reciprocated with a phase lag, however, in relation to the preceding plunger.

The output of each pump barrel depends on what portion of the helical head of the associated plunger registers with the port 205 during the plunger reciprocation. In order to adjust the output, that means in order to meter the quantity of fuel discharged through each valve 210, a pinion 221 is shrunk on or otherwise secured to each lower plunger end so that the plunger may be turned about its axis. The pinions 221 need not be provided with teeth about their entire circumference and it is sufficient if they form toothed segments according to the angle through which it is intended to render the plunger turnable for adjustment purposes. All the pinions 221 mesh with a centrally arranged gear wheel 222 which is mounted by bearing 223 on shaft 212. The wheel 222 which is hollow to receive therein the bearing 223 has an upward tubular extension 224. Into the latter and coaxially therewith another tubular member 225 extends which bears with a lower shoulder 226 upon a casing 227 supported by the outer race of the aforementioned bearing 223. Interiorly of casing 227 a spiral spring 228 is arranged the one end 228' of which is secured to the member 225 whereas the other end 228'' is fastened to the gear wheel 222. Two vanes 229 engage with their outer ends grooves 230 of the tubular extension 224 and are slidable with their inner ends 231 on the outer cylindrical surface 232 of the member 225. Owing to this arrangement the vanes 229 will be taken along when the wheel 222 with its extension 224 turns in relation to the member 225. The latter is also provided with oppositely positioned vanes 233 engaging in grooves 234 and being provided with segment-shaped extensions 235 which engage the inner cylindrical surface 236 of the wheel extension 224. In their normal position, the diameter on which the vanes 233 are arranged crosses the diameter on which the vanes 229 are located at approximately right angles so that four chambers 237, 238, 239 and 240 are formed interiorly of the wheel extension 224. The hollow space 241 of the member 225 is in communication with the chambers 237 to 240 by ports 242, 243, 244 and 245 respectively. Member 225 is closed at its top end at 246. A tubular guide member 247 bears with a lower flange 248 on the top rim 249 of the wheel extension 224. The aforementioned blades 233 are secured to flange 248 by means of pins 250 as clearly shown in Fig. 5, so that owing to the engagement of the vanes 233 with the member 225 the parts 225 and 247 are prevented from movement relatively to each other. Interiorly of

the guide member 247 (Fig. 4), a piston 251 is axially movable and a compression spring 252 is inserted between piston 251 and a plate 253 which bears on top of the member 225 and is rotatable within the flange 248 of the guide 247. Plate 253 has an upward extension 254 of tubular shape so as to fit into the lower portion of the tubular guide 247. The piston 251 is provided with lateral projections 255 which engage into slots 256 in the wall of guide 247 and also slots 257 in the tubular extension 254 of the blade 253. Either one of the pairs of slots may be helical and the other one straight lined in a direction parallel to the axis *b-b* or both pairs may be helical but turning in opposite directions. The upper end of the guide member 247 is formed as a pinion 258 which meshes with a rack 259 projecting laterally from the housing top piece 260 secured to the lower housing 201 by suitable means such as screws 261. The inner portion of the piece 260 forms a bearing surface 262 for the upper portion of the guide member 247. Housing portion 260 contains a conduit 263 which opens towards the outside at 264 and communicates on its inside with an annular chamber 265 surrounding the lower portion of the guide 247. Chamber 265 in turn can communicate with the aforementioned vane chambers 237 to 240 through the slots 256 and two recesses 266 and 267 in plate 253 which recesses are slightly larger in size than the width of the vanes 233 and are normally so positioned with respect to these vanes that in the relative position of Fig. 7 all the chambers 233 to 240 are connected with the chamber 265. A dome-shaped cover 268 is secured to the top housing 260 and encases two bellows 269 and 270. The bellows 269 is adjustably secured to the cover by a screw connection 271 with a conduit 272 for communication of the interior of the bellows with the atmosphere. The lower bellows 270 is suspended from the upper bellows 269 by a connection 273 which permits rotation of the one relatively to the other. Bellows 270 is attached by means of a hollow screw connection 274 to the interior of the guide member 247 on top of piston 251 so that the space 279 above the piston communicates with the interior of the bellows 270. The latter is preferably of a type which is temperature sensitive, so that with rising temperature it will bulge outwardly thereby increasing its capacity. It is filled with a liquid which when the bellows is subjected to outside pressure will cause the piston 251 to descend against the restraint of spring 252. Both the bellows 269 and 270 may be externally exposed to pressure or depression prevailing in the manifold of the engine to which the pump may be applied and for this purpose the top housing portion 260 is provided with an opening 275 into which a connecting pipe (not shown) may be screwed so that the entire inner space 276 of the housing top portion and the inner space 277 of the dome-shaped cover may be in communication with such manifold.

In order to operate the pump the interior of the shaft 212 is to be connected to a source of a hydraulic medium under pressure, preferably to the lubricating system of the engine to which the pump is to be applied. In the illustrated embodiment it is assumed that the lubricant is supplied through the hollow shaft 216. The inlet 278 is to be connected to a fuel source in order to feed the fuel into the chamber 206 which may be also provided with an outlet (not shown) for excessive quantities of the fuel which may cir-

culate through the chamber 206. The lubricant outlet 264 may be in communication with the oil well of the engine and the opening 275 may be in communication with the engine manifold as hereinbefore stated. Owing to its connection with the atmosphere the bellows 269 will be subjected to an interior pressure according to the surrounding air and, therefore, be sensitive to changes of the altitude. The bellows 270 together with the space on top of piston 251, on the other hand, is sensitive to changes of the temperature and manifold pressure as stated hereinbefore. In consequence, a decrease of altitude and an increase of temperature will act in the same way so as to increase the pressure on piston 251. Also, an increase of the depression in the engine manifold will have a similar effect. When the engine with the pump coupled thereto is operating, correct adjustment of the required pump output may be accomplished by shifting rack 259 which will cause guide 247 to turn. Gear wheel 223 will be taken along owing to the connection between flange 248, pins 250, vanes 233, center piece 225 and spring 228. Also, piston 251 and plate 253 will turn with the guide 247 so that the piston remains on its original level, and the recesses 266 and 267 keep the passage open from all four vane chambers 237, 238, 239 and 240 to the annular space 265. If now, the conditions under which the engine operates vary, increasing depression in the manifold will cause an expansion of the bellows 269. In consequence the latter will exert pressure on the top of the bellows 270 with the result that liquid from bellows 270 will be forced in the chamber 279 on top of the piston 251. Also, if the temperature decreases causing a contraction of the bellows 270, a portion of the liquid therein will be pressed into the mentioned chamber 279. The pressure exerted on the piston will force the latter downward against the restraint of spring 252 and the piston projections 255 sliding in the slots 256 and 257 will turn the plate 253 while guide 247 is maintained stationary owing to its engagement with rack 259. Originally, oil could flow through shafts 216 and 219 into the interior of the member 225 and from there through the openings 242 to 245 into the vane chambers 237 to 240 respectively. From there oil could escape through the gaps between the side walls of the plate recesses 266 and 267 and the vanes 233 and also pass from there into the ring space 265 and on through conduit 263 to the outlet 264. Now, when the plate is turned from the position shown in Fig. 7 in the one or other direction, the recesses 266 and 267 will slide over the top surfaces of the vanes 233 thereby closing two opposite vane chambers, for instance the chambers 238 and 240, while further opening the communication between the chambers 237 and 239 with the outlet. In consequence, oil pressure will rise in chambers 237 and 239 and decrease in chambers 238 and 240. The pressure difference will shift the vanes 229 accordingly and, together with them, rotate the gear wheel 222 which turns the plungers 203. Turning, however, of the wheel 222 will tension spring 228 owing to the connection of the latter with the member 225 and wheel extension 224. An equilibrium will be reached when the torque owing to the pressure difference acting upon the vanes 229 becomes equal to the torque due to the tension of the spring 228. Further, the pressure difference acting on the vanes 229 will be the larger the wider the recesses 266 and 267 open an outlet for the flow of the oil through the annular chamber 265. Such opening

however will be proportional to the distance piston 251 has been lowered and, owing to the engagement of the projections 255 with the slots 256 and 257, has turned the plate 253. When the pressure difference on the vanes 229 decreases the spring 228 will turn wheel 222 in the opposite direction and thereby adjust the plungers 203 accordingly. While, thus, a continuous oil current flows from the shaft 216 to the outlet 264 quantities of the lubricant may escape through a lateral bore 280 in shaft 212 into the lower housing space 281 so as to lubricate the movable parts of the pump including the faces of the plungers 203 provided with oil grooves and bores such as indicated at 282. From the space 281 the lubricant may return to the engine by passing through the bearing 213.

According to the arrangement and type of bellows of the embodiment just described, automatic adjustment of the pump output occurs in response to changes in external pressure and temperature. It will be understood, however, that the pump adjustment may be rendered responsive to changes of other external conditions, and that for such purpose it will be necessary only to select suitable elements reactive upon such other conditions and to adapt these elements so as to transmit their reactions on piston 251 in substitution for the bellows 269 and 273. Also, it will be understood that the invention is not limited to the particular hydraulic device illustrated in Figs. 4 to 7 and hereinbefore described. Thus the embodiment shown in Fig. 8 is provided with a modified drive for the adjustment of the plungers of the units. In other respects, the pump is similar to that shown in Fig. 4. The embodiment of Fig. 8 comprises a lower housing 301 with a number of barrels 302 in which plungers 303 are reciprocable by means of a swash plate drive 304. The cyclical tilting of the swash plate is derived from a shaft 305 adapted for connection to an engine shaft 306. Both shafts are hollow so that pressure oil may be forced through the shafts 306 and 305 and through a lateral opening 360 of the latter into the housing space 307. A disc-like part 308 comprising a discharge valve 309 for each barrel is secured between the lower housing 301 and a top housing portion 310, and a dome-shaped cover 311 is fastened to the latter and encases the altitude bellows 312 and the temperature- and pressure-sensitive bellows 313, all in coaxial arrangement. Housing 301 comprises an inner flange 314 which serves to hold a bearing 315 and an auxiliary shaft 316. Another bearing 317 for the auxiliary shaft 316 may be provided as shown in engagement with the bearing 318 of the drive shaft 305. A gear wheel 319 is keyed to the auxiliary shaft 316 at 320 and meshes with the pinions 321 of the plungers 303 similar to wheel 222 in mesh with pinions 221 in Fig. 4. A control drum 322 is also secured to the auxiliary shaft 316 and extends upward of flange 314 into the axial housing bore 323 which in its upper portion and including the central opening 324 of the disc 308 is lined with a cylindrical bushing 325. In engagement with the latter, a cup-shaped piston 326 is arranged for axial movement. To the lower head 327 of the piston one or several rollers 328 are pivoted on pins 329 which rollers engage in helical slots 330 provided in the wall of the drum 322. Piston 326 is biased by a compression spring 331 bearing against the top housing portion 310 into which a tube 332 is rotatably inserted. To the lower end of tube 332 two tubes 333 and 334 are secured e. g. by soldering, so as to extend downwardly, the one

inside the other with a space 338 therebetween. The outer tube 333 serving as a guide for piston 326 is slotted at 335 in axial direction, and the piston is provided with a pin 336 engaging slot 335 so as to prevent the piston from turning relatively to the tube. The inner tube 334 is closed at the bottom at 337, and an opening 339 is provided in its wall. There is also an opening 340 provided in the tubular part 332 to connect the interior of the latter with a ring space 341 in the top housing portion 310, and a conduit 342 leads from the space 341 to the outside at 343. The upper end of the part 332 is provided with peripheral teeth 344 with which a rack 345 meshes in an arrangement similar to the rack 259 of Fig. 4. A rod 346 is connected to the lower side of the bellows 313 and extends downward into the tubes 332 and 334 from which it is spaced by a spacer 347 which closes the upper end of the tube 332. At its lower end and at a distance therefrom, the rod is provided with two enlargements 348 and 349 which control the opening 339 of the tube 334. Rod 346 has an axial bore 350 which communicates through an opening 351 above enlargement 348 with the space 352 between the rod and the tubular part 332. Communication is also provided of the housing space 307 with the aforementioned space 352 between the tubes 333 and 334 through ports 353, 354 and 355 provided in the disc of wheel 319, in the flange 314 and the bottom of the drum 322 respectively.

The pump output can be manually adjusted by shifting the rack 345 in the one or other direction. Thereby, the tubular piece 332 will be turned and with it the extensions 333 and 334. Owing to the slot and pin connection 335 and 336 between the tube 333 and piston 326, and due to the rollers 328 engaging in the slots of the drum 322, the latter is taken along so as to turn the auxiliary shaft 316, the wheel 319 and the pinions 321. Thus, the plungers 303 will be adjusted according to the shifting of the rack 345. If on the other hand, the rack is held stationary, automatic adjustment will be accomplished in response to the expansion or contraction of the bellows 312 and 313. In the position of Fig. 8, the enlargement or valving portion 349 of rod 346 obstructs the slot 339. In consequence, as soon as the engine to which the pump is applied is started, oil pressure will build up in housing 307 and all spaces connected thereto, including the space underneath the piston bottom 327 which will rise according to the oil pressure and the restraint of spring 331. In rising, the rollers 328 move in the helical grooves of the drum 322, and as the piston 326 is prevented from turning owing to pin 336 in slot 335 of the tube 334 which is held stationary, the drum 322 will be turned together with auxiliary shaft 316 and wheel 319 so as to adjust the plungers to the conditions of the engine just started. If now the operating conditions of the engine change so that one or both of the bellows 312 and 313 expand, rod 346 will be shifted downward within tube 334, while the pressure underneath the rod and above the enlargement 349 is equalized through the bore 350 and the lateral hole 351. The downward movement of the rod shifts the enlargement 349 so that now an oil flow can set in through shafts 306 and 305, housing 307, holes 353, 354 and 355, space 338, opening 339, space 352 into the ring chamber 341 and from there through the conduit 342 to the outside or a return connection. This flow will decrease the pressure head on piston 326 which under the

action of spring 331 will be lowered and thereby turn the drum accordingly. The farther rod 346 is lowered the wider will be the opening offered to the oil flow and, consequently, the lower will be the position of the piston 326. Thus the piston position and as a result the position of the plungers 303 will depend on the expansion or contraction of the bellows 312 and 313.

It will be apparent to those skilled in the art that many alterations and modifications of the illustrated forms can be made without departure from the spirit and essence of the invention which shall be limited only by the scope of the appended claims.

I claim:

1. In a pump including a supply chamber, at least one pump unit having a barrel with an inlet aperture and a plunger reciprocable in the coordinate barrel, and a conduit between said supply chamber and said aperture, the combination of first means having a curved face in controlling relationship to said aperture and being movable in an axial direction and a peripheral direction, a second means whereby said plunger and said first means are held in fixed relationship and said plunger reciprocated and said means moved in one of said directions, third means including a hydraulic servo motor to cause movement of said first means in the other one of said directions thereby to change the portions of said face passing said aperture to vary the time during which said barrel is periodically connected to said supply chamber, a control element for said servo-motor, and a pressure responsive organ in controlling connection with said element so as to cause movement of said first means in said other direction according to pressure variations to which said organ is subjected.

2. A device as claimed in claim 1 wherein said pump includes a plurality of units arranged in an annular zone, equidistant from each other and parallel to a common axis, said first means, said hydraulic servo motor and said control element having an axis coinciding with said common axis and being located substantially in a cylindrical space central with respect to said annular zone.

3. In a pump including a plurality of units comprising each a barrel and a plunger reciprocable therein, a common inlet and metering valve in central arrangement with respect to said plurality of units, said valve being rotatable so as to serve said units one after the other and being axially shiftable to cause variation of the output of said units according to the level on which it rotates, said valve constituting a piston of a hydraulic device, means responsive to external pressure conditions, and a member connected to and shiftable by said pressure-responsive means and including a valving means of said hydraulic device to control the hydraulic pressure acting on said piston.

4. In a pump as claimed in claim 3, further comprising a second valving means of said hydraulic device, said second valving means being connected for common movement with said piston and being in cooperative relationship to said first valving means so that a pressure difference caused on the opposite sides of the piston by a shift of said first valving means will be equalized when said first and said second valving means are in their original relative positions.

5. In a pump including a plurality of units comprising each a barrel and a plunger reciprocable therein, a cylinder in central arrange-

13

ment with respect to said units, a common inlet and metering valve in said cylinder, said common valve being rotatable in said cylinder so as to serve said units one after the other upon its rotation, and being axially shiftable to cause variation of the output of said units according to the level on which it rotates, said valve constituting a piston of a hydraulic system, first conduits to admit a hydraulic fluid to the cylinder spaces respectively on either side of said piston, two second conduits in said piston to discharge fluid from said spaces respectively, and an axially movable valving means in controlling relationship to said second conduits so as to open one of said second conduits when moved in the one direction and to open the other second conduit when moved in the other direction, said second conduits being so arranged that a second conduit opened by a shift of said valving means will be closed when said piston is moved in the same direction.

6. A device as claimed in claim 5 further comprising a manually operative member in connection with said piston to shift it in axial direction, and means responsive to changes of external pressure conditions and in connection with said valving means to control the position of the latter.

7. A device as claimed in claim 5, said piston having an axial bore into which said second conduits open, said valving means being arranged interiorly of said bore and including a rod extending to one side beyond said cylinder, and a tube connected to said piston and surrounding said rod in a spaced relationship thereto so as to constitute a passage for the valved fluid.

8. In a pump including a plurality of units comprising each a barrel and a plunger reciprocable therein, a common inlet and metering valve in central arrangement with respect to said plurality of units, and being provided with an axial bore, said valve being rotatable so as to serve said units one after the other and being axially movable to cause variation of the output of the units according to the level on which it rotates, a hollow rotatable drive shaft passed through the bore of said valve and provided with an axially extending slot in its wall, a tubular member interiorly of said shaft, a pin in engagement with said slot and connecting said common valve to said tubular member, and a second valve interiorly of said tubular member, said common valve constituting a piston of a hydraulic device including conduits in said piston, said shaft and said tubular member to connect the spaces on either side of said piston to the interior of said tubular member, and said second valve being in controlling relationship to said conduits.

9. In a pump including a plurality of units comprising each a barrel and a reciprocable plunger turnable therein for the purpose of adjusting the output of its unit, the combination of a member in engagement with all the plungers to turn the latter, a hydraulic device to turn said member, an organ changeable as to its dimensions in response to changes of external conditions, and a control element of said hydraulic device and operative by said organ so as to control operation of said device according to changes of the dimensions of said organ.

10. A pump as claimed in claim 9, wherein said control element comprises two members, the one being in engagement with helical faces of the other one, to transform axial movement of the one into rotary movement of the other.

11. A pump as claimed in claim 9 wherein said hydraulic system comprises a piston, guiding

14

means for said piston to prevent the latter from turning, and a connection between said member and said piston, said connection including helical guide faces to transform axial movement of the piston into turning movement of said member.

12. In a pump including a plurality of units comprising each a barrel and a reciprocable plunger turnable for the purpose of adjusting the output of its unit, a gear wheel in engagement with all said plungers, said wheel including a hollow cylindrical extension and a first pair of diametrically opposite vanes projecting inwardly from the walls of said cylinder, a normally stationary shaft coaxially with and interiorly of said cylinder and including a second pair of vanes projecting towards the wall of said cylinder and intermediate said first vanes respectively so as to form a chamber between each two adjacent vanes, means to conduct a hydraulic fluid to said chambers, a valving means for the discharge of equal quantities of fluid from opposite chambers, and means to adjust said valving means so as to cause pressure differences in each two adjacent chambers and thereby to turn said first pair of vanes with said cylinder and wheel.

13. A device as claimed in claim 12 further comprising a spring in connection with said cylinder and said shaft, so as to be tensioned when the cylinder is turned relatively to said shaft in one direction.

14. A device as claimed in claim 12 wherein said valving means comprises a rotatable cover of said cylinder and provided with two diametrically opposite openings, each of said openings being of sufficient size to communicate with two adjacent chambers when said openings are in registry with the second pair of vanes.

15. A device as claimed in claim 12 wherein said valving means comprises a cover plate of said cylinders, said plate being turnable about the axis of said shaft and provided with discharge openings, and said means to adjust said valving means comprises an axially movable member, an axial extension of said plate and a connection between said axially movable member and said plate extension, said connection including helical guide faces to transform axial movement into rotation.

16. In a pump including a plurality of units comprising each a barrel and a reciprocable plunger turnable therein for the purpose of adjusting the output of its unit, the combination of a wheel in engagement with all the plungers to turn the latter, a hydraulic device in connection with said wheel to turn it, an organ changeable as to its dimensions in response to changes of external conditions, a control element of said hydraulic device and operative by said organ so as to control operation of said device according to changes of the dimensions of said organ, and manually operative means in connection with said hydraulic device and said wheel to turn both said device and said wheel together independently of said organ.

17. In a pump including a plurality of units comprising each a barrel and a reciprocable plunger turnable therein for the purpose of adjusting the output of its unit, the combination of a wheel in engagement with all the plungers to turn the latter, a drum connected to said wheel for common rotation, a cylinder coaxial with said wheel, a piston reciprocable in said cylinder, a connection including helical faces between said drum and said piston, a compression spring between the cylinder bottom and the one side of said piston, means to admit a hydraulic fluid to

15

load the other side of said piston, means to discharge fluid, an organ responsive to changes of external condition, and a valve for said discharge and connected to said organ so as to adjust the discharge cross-section according to the reaction of said organ on said valve.

18. A device as claimed in claim 17 further comprising a first tube extending axially into said cylinder including means to prevent said piston from rotating relatively thereto, a second tube interiorly of and spaced from the first one so as to constitute a discharge conduit, a spacer member secured to the end portions of said tubes remote from said piston so as to close said conduit, a discharge opening in the side wall of said second tube, said valve controlling said opening, and manually operative means to turn said spacer and with it said tubes, piston, drum, and wheel independently of said valve.

LOUIS BEEH.

5

10

20

REFERENCES CITED

The following references are of record in the file of this patent:

16

UNITED STATES PATENTS

Number	Name	Date
2,093,477	Parsons	Sept. 21, 1937
2,131,857	Lauret	Oct. 4, 1938
2,160,735	Hoffer	May 30, 1939
2,357,563	Truxell	Sept. 5, 1944
2,370,506	Tabb	Feb. 27, 1945
2,380,574	Beeh et al.	July 31, 1945
2,388,462	Beeh	Nov. 6, 1945
2,391,221	Beeh	Dec. 18, 1945

FOREIGN PATENTS

Number	Country	Date
198,793	Switzerland	Sept. 16, 1938
499,242	Great Britain	Jan. 20, 1939

OTHER REFERENCES

Serial No. 288,980, Blechl (A. P. C.), published May 11, 1943.